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ABSTRACT

This study was designed to identify students' misconceptions concerning frictional force, and Newton's laws of motion. It was also designed to determine the effectiveness of using instructions based on students' misconceptions to improve the teaching of physics. A pencil-and-paper test was administered to three groups of 16-year-old students: average students, above average students, and gifted students. Some common misconceptions were listed and comparisons of misconceptions among the three groups were illustrated. To ovecome students' misconceptions, a teaching unit with instructional materials using students' misconceptions was designed. The instructional strategy suggested by the principle of conceptual change was developed for students in the experimental group. Statistical analysis of data showed that students in the experimental groups performed significantly better and with fewer misconceptions as compared with students who learned the same concepts and laws through the usual way of lesson delivery. A 20-item test for identifying the misconceptions is appended. (YP)

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MISCONCEPTIONS CONCERNING LAWS OF MOTION, FRICTIONAL FORCE AND WORK DONE AMONG STUDENTS OF DIFFERENT ABILITIES AT UPPER SECONDARY LEVEL

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ABSTRACT

In recent years, a considerable amount of attention has been focused on students' misconceptions in physics. Many students share more or less the same misconceptions about the physics concepts and laws they have learnt. Ignorning them makes the teaching of physics ineffective as indicated by many research studies. This study aimed: (a) to identify students' misconceptions concerning frictional force, Newton's laws of motion and work done from samples of students of different abilities; and (b) to investigate the effectiveness of using instructions based on students' misconceptions to improve the teaching of physics. A pencil and paper test was administered to three groups of secondary four students. The misconceptions among students were summarized and analysed according to: (a) their understanding of definitions, concepts and laws based upon physics phenomena; and (b) their abilities to analyse the phenomena using integrated networks of concepts and propositions. To overcome students' misconceptions, a teaching unit with instructional materials using students misconceptions was designed. The instructional strategy suggested by the principle of conceptual change was developed for students in the experimental group. Statistical analysis

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of data showed that students in the experimental groups performed significantly better and with much less misconceptions as compared with students learned the same concepts and laws through usual way of lesson delivery. This study confirms that it is important for teachers to take into consideration of students' misconceptions when designing their instructional materials and teaching strategy.

Introduction

Misconceptions in Physics amongst secondary school students are not uncommon. Even students who do well on textbook problems and Physics tests often do not show confidence in applying Physics concepts and laws they have learned to explain Physics phenomena as well as to solve Physics problems. Students' failure are not due to the absence of theories but rather due to the persistence of misconceptions they have. In recent years, a considerable amount of attention has been focused on students' misconceptions and the causes of misconceptions in Physics. Reports show that the main causes of misconceptions are due to teachers, teaching method, intuitive ways of reasoning from everyday experience, textbook errors, ill conceived examination papers, mismatch between students' intellectual development and the demands of the course contents. To overcome students' misconceptions educators will have first to identify the common misconceptions held by the students.

This is of much value in the teaching and learning process because knowing the students' misconceptions teachers can assume the role of diagnostician and prescriber of appropriate learning activities which geared towards the understanding of physics.

Purpose of Study

The study is aimed at:

(a) identifying and analysing students' misconceptions concerning frictional force, laws of motion and work done amongst gifted, above average and average achieving students;

(b) designing instruction using students' misconceptions and developing conceptual change instructional strategies for students in the experimental group to deal with and to alleviate the common misconceptions;

(c) examining into the effects of using instruction based on common misconceptions and conceptual change strategies on students' understanding of physics concepts/laws as well as their abilities in applying physics concepts/laws in interpreting/analysing physics phenomena and solving physics problems.

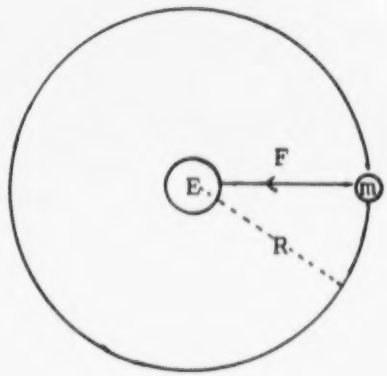
Method

Identification of Misconceptions

To find out the misconceptions held by the students an interview was conducted to a small group of students. From the results of the interview a pencil and paper test was devised which consisted of twenty items on topics: friction, laws of motion and work done. The questions were grouped according to cognitive notion of schema: (a) definitions and ideas based upon physics phenomena, laws and principles, specific relationship between two or more concepts; (b) analysis or interpretation of phenomena using integrated networks which incorporates concepts and propositions. Each item of this misconception test consisted of two parts. The first part was a multiple-choice question with common or suspected misconceptions used as the distractors of the question so that the misconceptions could be in some sense be summarized. The second part of the item required the students to give their reasons or explanation pertaining to the answer which they had chosen. The test items have been discussed with forty-one inservice course participants. All of them are qualified and experienced teachers with four to twenty years teaching experiences in Physics. Samples of the questions are given in the boxes below:

Understanding of Scientific Definition of Work Done

The moon revolves round the earth and held in its orbit by a force due to the earth acting towards its center. Is there any work done by this force?



A. W = O J

B. W = F . R

C. W = F . 2πR

D. W = F . 2R

E. None of the above

Explain your answer

Understanding of Static Frictional Force

A block of mass 10 kg will start to move when a force of 20 N acts on it. Find the frictional force if a force of 10 N is applied on the block.

A 10 N (--->)

B 10 N (<---)

C 20 N (--->)

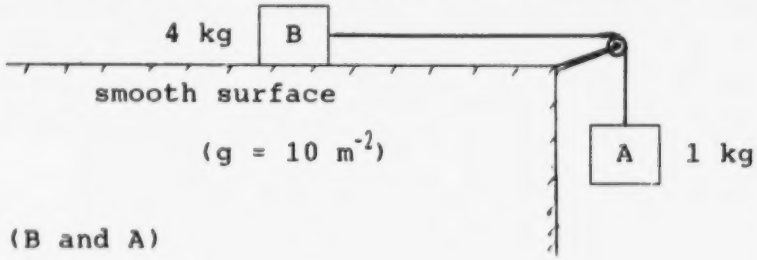
D 20 N (<---)

E zero N

Explain your answer

Application of Newton's 2nd Law in Solving a Physics Problem

In the arrangement shown, block B slides on a smooth surface. What are the accelerations of the blocks?



A 2 ms^{-2} (B and A)

B 2.5 ms^{-2} (B and A)

C 2 ms^{-2} (B); 10 ms^{-2} (A)

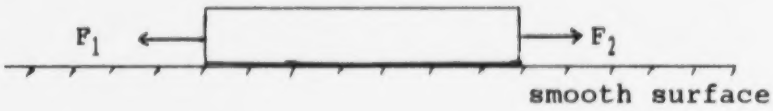
D 2.5 ms^{-2} (B); 10 ms^{-2} (A)

E 2.5 ms^{-2} (B); 0 ms^{-2} (A)

Give reasons for your choice

Analysis of the Situation by Applying Correctly the Newton's First Law

An object is moving under the influence of a force (F_1). At a certain point, an opposing force (F_2) of the same magnitude is imposed on it.



What will happen to the object?

A. The box will slow down.

B. The box will move continuously at constant velocity.

C. The box will come to rest immediately after the opposing force imposed on it.

D. The box will move continuously but with less acceleration.

E. The box will finally move along the backward direction.

Explain your answer

Sample

The test was administered to four groups of 148 secondary four students. Details of the samples used are set out in Table I.

TABLE I.
Samples used for the study

Sample	Average achieving students (Group 1)	Above-average achieving students (Group 2)	Gifted students (Group 3)	Above-average achieving students (Group 4)
No. of students	36	30	42	40
Age	16	16	16	16

Students involved in this study had already received formal Physics instructions. The topics under investigation were usually introduced briefly and qualitatively in lower secondary science course and taught formally in more detail in upper secondary Physics course. Groups 1, 2 and 3 were subjected to the conventional instruction while group 4 was treated as an experimental group with instruction designed according to common students' misconceptions.

Instruction Materials for the Experimental Group

As the objective of physics teaching is to assist students to understand physics concepts and laws accurately, as well as to apply these concepts and laws to interpret

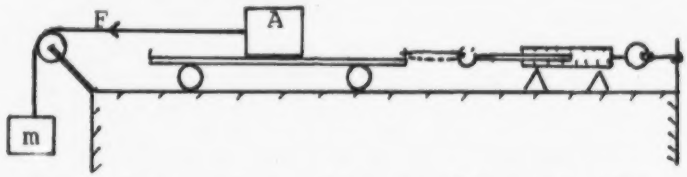
phenomena and to solve problem, physics educators must first find out common misconceptions amongst students. Secondly, there is a need of exploring appropriate teaching methods to overcome students' misconceptions. These include helping them to recognize common misconceptions and how the misconceptions as being unsatisfactory, unsuccessful and inconsistent when applied to analyse and to interpret more complicated physics phenomena and problems. This can be done through well-chosen learning experiences which highlight: (a) the inadequacies of students' misconceptions; (b) the scientific concepts which are intelligible, internally consistent, fruitful and able to reconcile with their existing conceptions; and (c) the scientific concepts can be used to resolve problems and to provide explanatory and predictive power. In designing the instructional materials aimed for improving students' understanding of scientific concepts as well as avoiding creation of misconceptions, teachers need to be familiar with students' conceptions. In this study, the instructional materials developed for the students in the experimental group are based on rather than ignoring students common misconceptions. Demonstrations, activities and explanations are the essential constituents of the treatment. Example on frictional force is given in the box below:

Static Frictional Force

Suggested Activity/Demonstration/Explanation

The aim here, is to show that the frictional force acting on a block A by the floor of the trolley is equal to the applied force (F) acting on the block when F is not enough to move the block.

- The set-up of the experiment is shown in the diagram below:



- For different values of m, the reading of the spring balance should be about equal to mg if the force mg is not enough to move the block A.
- Convince the students, through an analysis of the forces in the system, that the spring balance reading represents the frictional force between the block A and the floor of the trolley.
- Help the students to reason out that if m is zero, that is, no force acts on block A, then the reading on the spring balance will be zero, implying that the frictional force between block A and the floor of the trolley is zero.
- Highlight the points that static frictional force is always equal in magnitude to the applied force.

Teaching Strategies Adopted for the Experimental Group

Learning is not just the addition of new knowledge but involves the interaction of new conceptions with existing conceptions and real-life experiences. Teaching of Physics will become more effective if teacher can predict the teaching outcome especially students' possible misunderstanding of concepts and theories and plan the lessons in accordance with such common misconceptions. In order to alleviate students' misunderstandings in the learning of physics, the teaching strategies must include:

- Incorporation of new scientific conceptions with students' existing conceptions as well as the common misconceptions.
- Differentiation of common misconceptions into more clearly defined and separated components for the purpose of highlighting what was plausible in one situation is no longer plausible in another situation.
- Change of misconceptions for scientific conceptions through emphasis on dissatisfaction of the misconceptions.
- Linking of practice and theory as well as conceptual bridging of scientific concepts with meaningful common experiences and experiments.

The conceptual framework of the treatment process is shown in Figure 1.

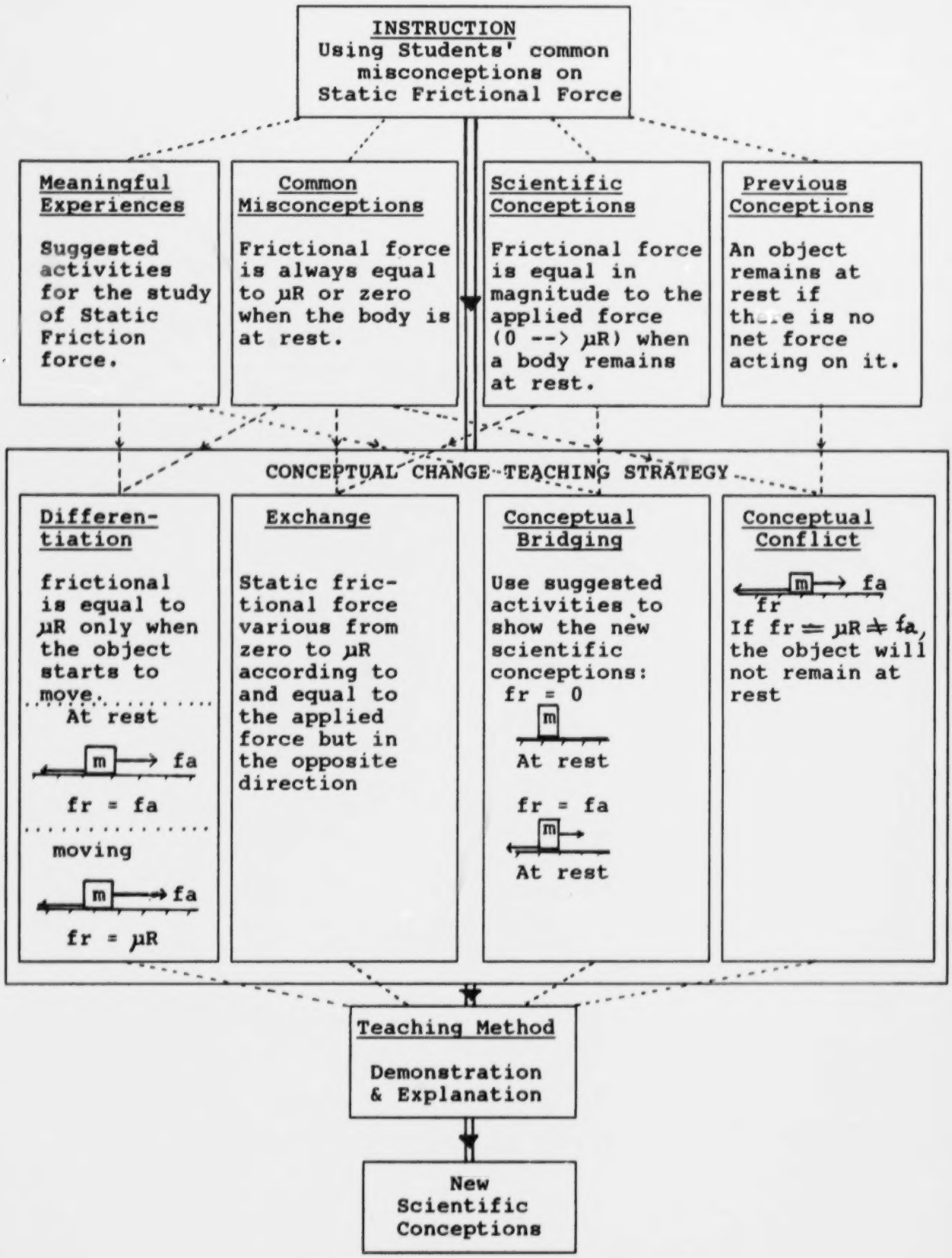

INSTRUCTION
Using Students' common misconceptions on Static Frictional Force
Meaningful Experiences
Suggested activities for the study of Static Friction force.
Common Misconceptions
Frictional force is always equal to μR or zero when the body is at rest.
Scientific Conceptions
Frictional force is equal in magnitude to the applied force (0 --> μR) when a body remains at rest.
Previous Conceptions
An object remains at rest if there is no net force acting on it.
CONCEPTUAL CHANGE TEACHING STRATEGY
Differen-tiation
frictional is equal to μR only when the object starts to move.
At rest
m
fa
fr = fa
moving
m
fa
fr = μR
Exchange
Static frictional force various from zero to μR according to and equal to the applied force but in the opposite direction
Conceptual Bridging
Use suggested activities to show the new scientific conceptions:
fr = 0
m
At rest
fr = fa
m
At rest
Conceptual Conflict
m
fa
fr
If fr = μR ≠ fa, the object will not remain at rest
Teaching Method
Demonstration & Explanation
New Scientific Conceptions

Figure 1 Conceptual Framework

Results and Discussion

The data collected for this study were obtained from the test administered to three groups of students of different abilities and a group of students who had undergone the treatment with instruction using students' common misconceptions.

Some Common Misconceptions

Analysis of students' responses to the written test indicates that most of the students share the following misconceptions.

(a) *Frictional Force*

- Frictional force always exists and equals in magnitude to the applied force which required to start to move the object.
- When an object remains at rest there is no frictional force regardless of whether there is any applied force acting on it.
- The direction of the frictional force is always considered to be in the opposite direction of the moving object instead of considering in the opposite direction to the tendency of motion of the object relative to the surface at the contact surface.

(b) *Newton's 1st Law*

- Pupils link velocity to force instead of relating force with acceleration.
- Pupils have not captured the essence of the law of inertia. When two equal and opposite forces acting on an object, the object become at rest or slow down instead of considering the possibility of the object moving with constant velocity if the velocity of the object is not zero at that time.

(c) *Newton's 2nd Law*

- The reading of the weighing machine about the weight of the man inside a lift remains constant because the gravitational pull is the same whether the lift is accelerating or moving with constant speed upwards or downwards.
- When the lift and also the man starts to accelerate downwards, the man exerts an extra downward force acting on the weighing machine, so its reading increases.
- When the lift moves upwards, it exerts an upward force on the man and hold the man up, so the reading of the weighing machine decreases.

(d) *Newton's 3rd Law*

- Students misunderstand that action and reaction are acting on the same body.
- Students confuse action/reaction with external balancing forces as well as with the tension.

(e) *Work Done*

- Students misconstrue the scientific definition of work done when the object moves in the direction which is not along the direction of the force acting on it.
- In circular motion, students find it difficult to visualize the exerted force towards the center always perpendicular to instantaneous displacement of the object along the tangent direction.

Comparison of Misconceptions Amongst Students of Different Abilities

Graphic illustrations of the results of the test about students' responses to items concerning understanding of Physics concepts/Laws as well as application of concepts/Laws in analysing more complicated Physics situations are given in Figure 2 (a) and 2 (b) respectively.

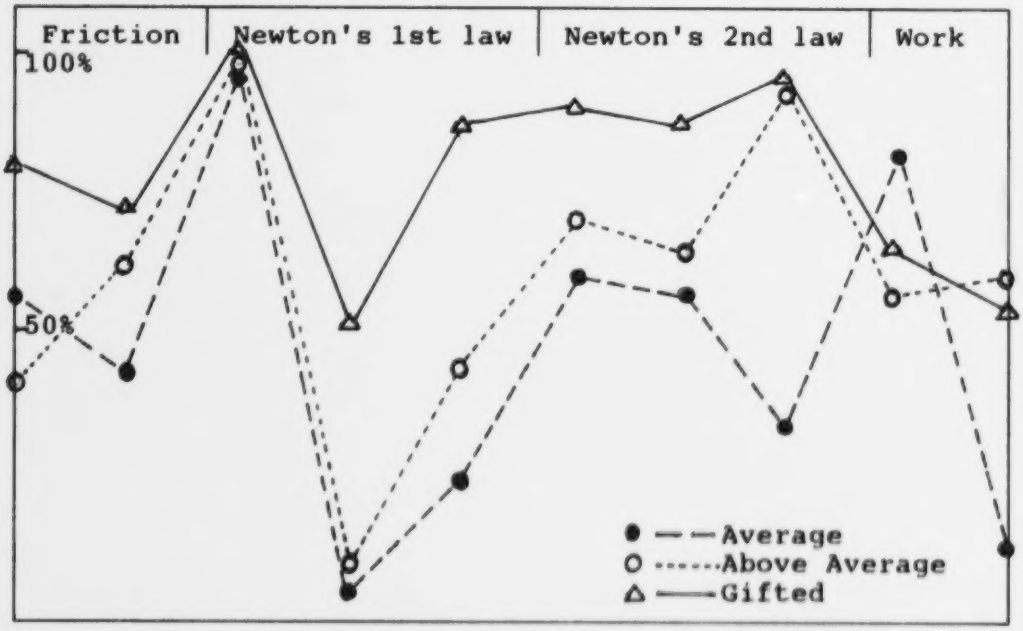


Figure 2(a) Percentage of correct responses to items related to the understanding of Physics concepts and laws

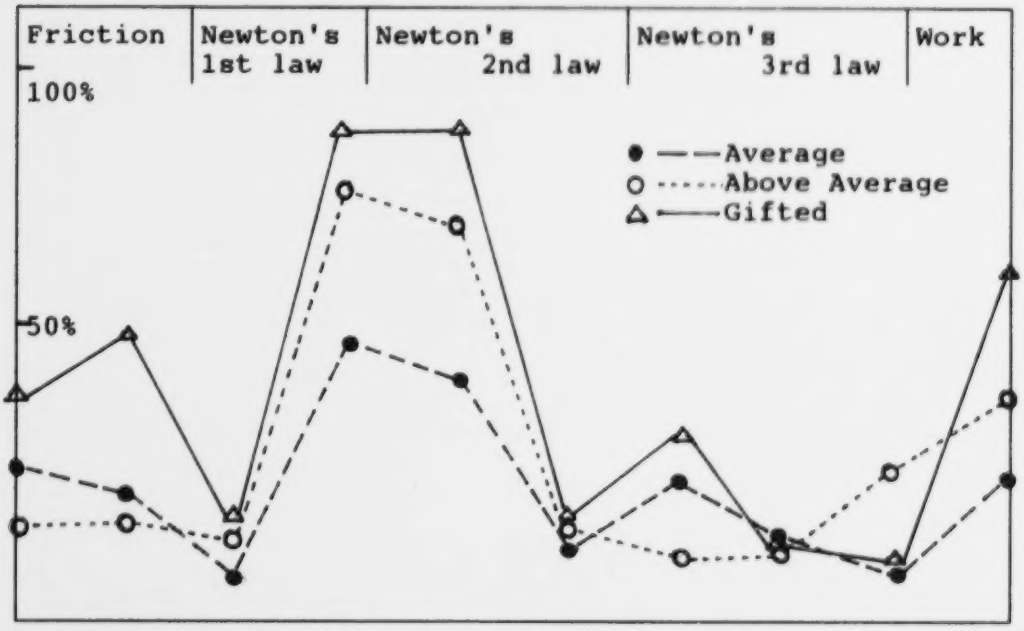


Figure 2(b) Percentage of correct responses to items concerning the application of Physics concepts and laws in analysing more difficult Physics problem

The results indicate that:

- Students from the gifted group understand physics concepts/Laws much better than the above-average students and the above-average students have less misconceptions as compared with average achieving students. Nevertheless, there are still 20% to 50% of the gifted students hold some common misconceptions on static frictional force, Law of inertia concerning constant velocity of a moving object, work done when the force acting on an object and the instantanous displacement of the object are not in the same direction.
- Generally, students from the gifted group are more confident in applying physics concepts/laws in solving physics problems. However, over 70% of the students including the gifted group answer incorrectly the items which require analysis of physics problems using several physics concepts and laws. Though there is quite a high percentage of students who can apply Newton's Second Law to solve some common physics problems, still about 90% percent of the students have difficulty in applying the law to solve problem with system consisting of two or more objects.

- Most of the students are unable to apply correctly Newton's third law and concepts of static frictional force to interpret/explain relevant physics phenomena.

Analysis of Variance

The statistical technique known as the ANOVA is used to determine whether the differences among means (M_{AVE}, M_{A-AVE} and M_G) are greater than would be expected by chance alone. The calculated F-ratio of 47.95 for understanding physics concepts/laws and 18.25 for applying physics concepts/laws are very large enough to reject the null hypothesis with $\alpha = 0.05$. Rejecting H_0 is equivalent to concluding that two or more means are not equal. To determine which pairs of sample means are significantly different, the Tukey method of multiple comparison is employed to compute the q-value which is used to test the three Ho's involving pairs of means. The results are given in Table II (a) and II (b).

TABLE II(a)
Comparison of pairs of groups means of students' performances about understanding of physics concepts and laws

Group	Average (GP.1)	Above Average (GP.2)	Gifted (GP.3)
q-value	$q_{21} = 4.45$		$q_{32} = 8.71$

TABLE II(b)
Comparison of pairs of group means of students' performances concerning the ability of applying physics concepts and laws in solving physics problems

Group	Average (GP.1)	Above Average (GP.2)	Gifted (GP.3)
q-value	$q_{21} = 0.471$		$q_{32} = 6.79$

The results of the studentized range (q) indicate that:

- There are significant differences between gifted and above-average students both in the areas on understanding and applying physics concepts and laws.
- There is significantly different in understanding physics concepts and laws between students from the above-average and average group but there is no significant difference between the two groups in applying physics concepts and laws in analysing physics phenomina and solving complicated physics problems.

The Effects of Treatment Using Suggested Instruction and Teaching Strategy on Alleviation of Students' Misconceptions

To determine the effects of the treatment provided to the experimental group (Gp 4) on alloviation of students misconceptions, analysis of the data collected from the experimental group (Gp 4) and the control group (Gp 2) was done by using t-test as well as estimating the difference between sample proportions.

(a) Comparison of students' performances using t-test

The means for both experimental and control groups, the standard errors of the difference in means and the t-test results concerning items about student's understanding of Physics concepts/laws and about student's ability in the application of concepts/laws are given in the Tables III(a) and III(b).

TABLE III(a)
Results about understanding of Physics concepts/laws

Experimental Group Mean ($\bar{x}_1$)	Control Group Mean ($\bar{x}_2$)	$S\{\bar{x}_1-\bar{x}_2\}$	t-value	Decision
9.25	5.73	0.302	11.63	Reject Ho at α = .05

TABLE III(b)
Results about application of Physics concepts/laws

Experimental Group Mean ($\bar{x}_1$)	Control Group Mean ($\bar{x}_2$)	$S\{\bar{x}_1-\bar{x}_2\}$	t-value	Decision
5.83	2.07	0.317	11.85	Reject Ho at α = .05

From the post-test results, we see that the experimental group has performed much better than the control group. Thus it can be concluded that the teaching units have been successful, ie. by placing emphasis on instruction using students' common misconceptions as well as implementation of conceptual change strategy during physics lessons, students' misconceptions can be effectively alloviated.

(b) Comparison of correct responses to each test item between students in the experimental and the control group

To examine into the treatment effect on understanding or applying a specific concept or law, we compare the percentage of correct responses to each test item from students of the experimental group with that of the control group. Summary of the proportion comparisons of the two groups is shown in the Tables IV(a) and IV(b).

TABLE IV(a)
Comparison of correct responses to items about Understanding of Physics concepts and Laws

Topics	Experimental Group $\bar{P}_1$	Control Group $\bar{P}_2$	$S\{\bar{P}_1-\bar{P}_2\}$	t
Frictional Force	.850	.400	.1146	3.927 *
	.925	.600	.0991	3.280 *
Newton's First Law	.575	.067	.1157	4.391 *
	.975	.433	.1055	5.166 *
Newton's Second Law	.950	.700	.0879	2.844 *
	.975	.633	.0911	3.754 *
	.975	.933	.0490	0.857
Work Done	.905	.567	.1031	3.784 *
	.950	.600	.0966	3.623 *

* $P<0.05$

TABLE IV(b)
Comparison of correct responses to items concerning about Application of Physics concepts and laws

Topics	Experimental Group $\bar{P}_1$	Control Group $\bar{P}_2$	$S\{\bar{P}_1-\bar{P}_2\}$	t
Frictional Force	.600	.100	.1175	4.255 *
	.725	.100	.1203	5.195 *
Newton's First Law	.475	.100	.1121	3.345 *
Newton's Second Law	.975	.733	.0810	2.988 *
	.975	.667	.0879	3.504 *
	.325	.100	.1013	2.221 *
Newton's Third Law	.525	.150	.1161	3.230 *
	.125	.067	.725	0.800
	.050	.033	.0490	0.347
Work Done	.975	.367	.1091	5.573 *

* $P<0.05$

The results given in the tables show that students in the experimental group perform much better on most of the items than students in the control group. This indicates that students in the experimental group have gained mastery of most of the concepts and laws. However, there are certain areas related to the application of concepts and laws needed for further improvement. Students in the experimental group have difficulty in applying Newton's second law to solve problem of more complicated system. They still lack in experience in applying Newton's third law and conservation of momentum to analyse certain relatively difficult situations.

Summary

Misconceptions in physics amongst secondary school students are not uncommon. It is also not surprising that even there are quite high percentage of students from the gifted group hold some common misconceptions especially concerning the application of physics concepts/laws to interpret relatively more complicated phenomena. As the objective of physics teaching is to assist students learn to actively modify and re-structure their own ideas to the scientific concepts, teachers will have first to find out the common misconceptions held by the students in different topics in physics. Secondly, where is a need to develop instructional materials using students' misconceptions as well as to explore effective teaching approaches to alleviate students' misconceptions. The results obtained from this study strongly support the notion that with emphasis on instruction developed taking into consideration of students' common misconceptions as well as implementation of conceptual change strategy in the teaching of physics, students would perform much better in understanding accurately the physics concepts/laws and applying with confidence the concepts/laws to solve physics problems.

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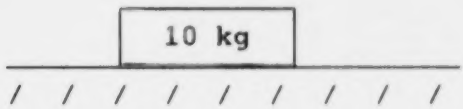
1. A body of mass 10 kg will start to move when a force of 40 N acts on it. Find the frictional force acting on the body when it is at rest.



A. 40 N (——>)

B. 40 N (<——)

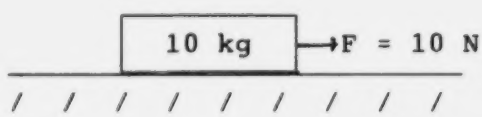
C. zero N

D. 40 N (↓)

E. 40 N (↑)

Explain your answer.

2. A Block of mass 10 kg will start to move when a force of 20 N acts on it. Find the frictional force if a force of 10 N is applied on the block.



A. 10 N (——>)

B. 10 N (<——)

C. 20 N (——>)

D. 20 N (<——)

E. zero N

Explain your answer.

3. We are able to walk because there is friction between our feet (or footwears) and the ground. When the man is walking forward, what are the direction of the frictional forces on the man by the ground and that on the ground by the man?

A. <----, ---->

B. <----, <----

C. ---->, ---->

D. ---->, <----

E. No definite direction

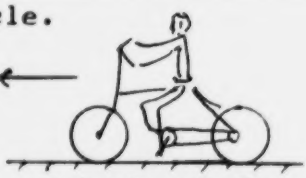
Explain your answer.

_____

_____

_____

4. A person is riding a bicycle.



In which direction will the frictional force act on the rear wheel and in which direction will the wheel rotate?

A. ----> ↻

B. <---- ↺

C. <---- ↻

D. ----> ↺

E. No definite direction

Explain your answer.

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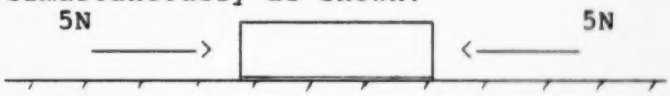
5. A box is initially at rest. Two forces are then acting on the box simultaneously as shown.



The box will

A. accelerate towards the left.

B. accelerate towards the right.

C. move with constant speed towards the left.

D. move with constant speed towards the right.

E. remain at rest. ☐

Explain your answer.

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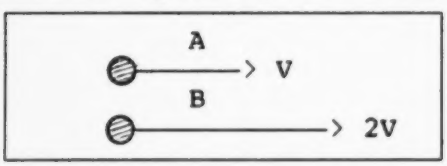
6. Object A and B both move at constant speed along a smooth surface. If speed of B is faster than speed of A, then



A. only object B experiences a force acting on it.

B. object B experiences a greater force acting on it than that on object A.

C. there is no net force acting on both object A and B.

D. both objects A and B experience equal forces acting on them.

E. object A experiences a net force against its motion. ☐

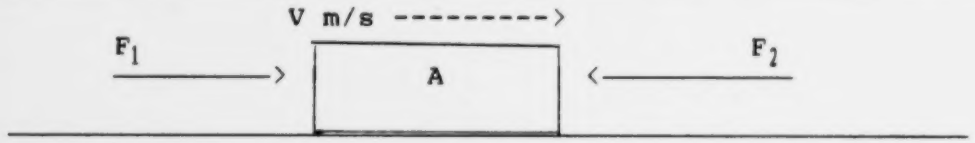
Explain your answer.

_____

_____

_____

7.



If two equal forces F_1 and F_2 act on the object A which is initially moving with a constant speed, then

A. object A would go faster.

B. object A would move in a straight line with the same speed.

C. object A would slow down.

D. object A would come to rest.

E. object A moves with the same speed but the direction of its motion changes. ☐

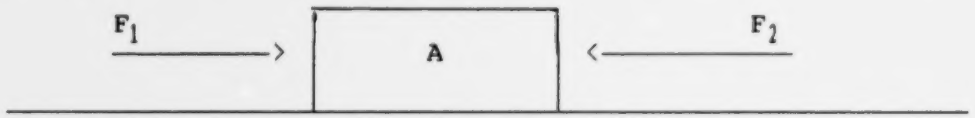
Explain your answer.

_____

_____

_____

8. An object is moving under the influence of a force (F_1). At a certain point, an opposing force (F_2) of the same magnitude is imposed on it.



What will happen to the object?

A. The box will slow down.

B. The box will move continuously at constant velocity.

C. The box will come to rest immediately after the opposing force imposed on it.

D. The box will move continuously but with less acceleration.

E. The box will finally move along the backward direction. ☐

Explain your answer.

_____

A 60 kg man stand on a weighing machine placed inside a lift. The reading of the weighing machine (W) would be:

A. W > 60 kg(f)
B. W = 60 kg(f)
C. W = 0 kg(f)
D. W < 60 kg(f)
E. None of the above

9. What does the scale read when the lift starts to accelerate upwards? ☐

Give reasons for your choice.

_____

_____

_____

10. What does the scale read when the lift is moving upwards at constant speed? ☐

Why do you think so?

_____

_____

11. What does the scale read when the lift start to accelerate downwards? ☐

Why do you think so?

_____

_____

_____

12. What does the scale read when the lift descends at a constant speed? ☐

Explain why?

_____

_____

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13. What does the scale read when the lift falls freely? ☐

Why do you say so?

_____

_____

14. In a tug of war, one team pulls on the rope with a force of 500N while the other pulls in the opposite direction with a force of 500N. What is the tension in the rope?

A. 500N

B. zeroN

C. 1000N

D. 2000N

E. None of the above

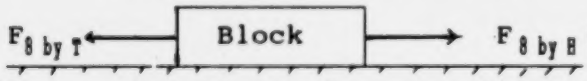
Why do you say so?

_____

_____

15. Figure shows forces acting on a block.

(The block is not moving)



($F_{B\ by\ T}$: frictional force on block B by table T)

Statements:

1. $F_{B\ by\ T}$ and $F_{B\ by\ H}$ is a pair of action and reaction forces.

2. $F_{B\ by\ H} < F_{B\ by\ T}$.

3. $F_{B\ by\ H} = F_{B\ by\ T}$, but they are not action and reaction forces.

4. The block does not move because the force exerted by the hand is not enough to overcome the static frictional force on the block.

Which of the above statement/s is/are correct?

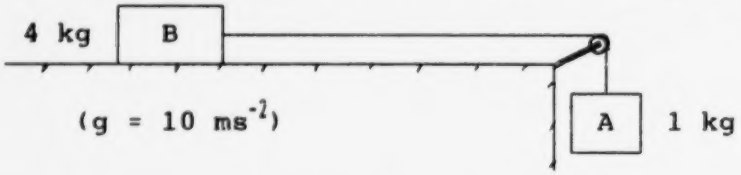
A. 4 only.
B 3 and 4.
C. 2 and 4.
D. 2 only.
E. 3 only.

Why do you think so?

_____

_____

16. In the arrangement shown, block B slides on a smooth surface.

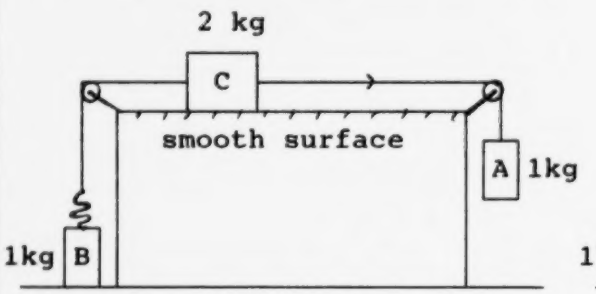


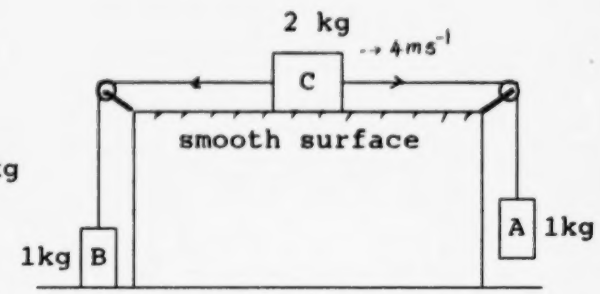
What are the accelerations of the blocks?

A. 2 ms^{-2} (B and A)
B. 2.5 ms^{-2} (B and A)
C. 2 ms^{-2} (B); 10 ms^{-2} (A)
D. 2.5 ms^{-2} (B); 10 ms^{-2} (A)
E. 2.5 ms^{-2} (B); 0 ms^{-2} (A)

Give the reasons for your choice.

17. An object C is moving under the influence of a force due to object A. When the speed of object C reaches 4 ms^{-1}, an opposing force due to object B is imposed on it.





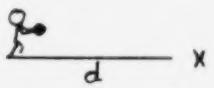
The object C will

A. move at constant speed, 4 ms^{-1}
B. move at constant speed, 3 ms^{-1}
C. come to rest immediately when the opposing force is imposed on it.
D. slow down with an acceleration of -5 ms^{-2}.
E. speed up continuously with an acceleration of 5 ms^{-2}.

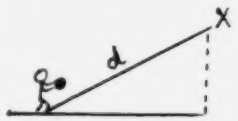
Explain your answer.

The diagrams show a man carrying a stone of mass 1 kg to a point X.

(a)

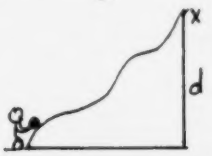


(b)

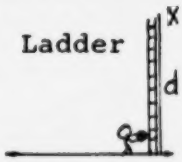


(c)

(d)



(e)



18. Which diagrams show that the amount of work done by the man are the same?

A. (a) and (e) only.
B. (b) and (c) only.
C. (b), (c) and (d).
D. (a), (b), (c) and (e).
E. (c), (d) and (e).
Explain why?

_____

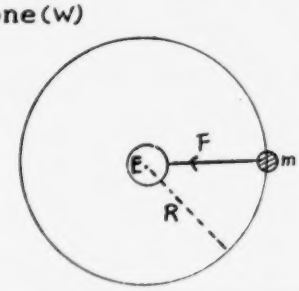
19. Which diagram/s indicate(s) that no work is done on the stone?

A. (a) only.
B. (b), and (c).
C. (b), (c) and (e).
D. (e) only.
E. (a) and (b).
Give your reasons, why?

_____

20. The moon revolves round the earth and held in its orbit by a force due to the earth acting towards its center. Is there any work done(W) by this force?

A. W = O J
B. W = F . R
C. W - F . 2πR
D. W = F . 2R
E. None of the above.
Explain your answer.



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